

## iGEM Activities at TouchTomorrow

TouchTomorrow is an event held at Worcester Polytechnic Institute each year. This event focuses on presenting STEM ideas and concepts to the WPI and Worcester community in a fun way. TouchTomorrow was geared toward children but parents and adults were more than welcome to participate in the events. This year around 10,000 people attended TouchTomorrow, while about 400 of those attended the biology section run by the iGEM team.

For the TouchTomorrow event, the WPI iGEM team adapted some of the activities put together by the iGEM team at the College of William and Mary in their manual “Synthetic Biology Teacher Curriculum” in order to accommodate a large crowd of people. The activities at the event were: Twizzler DNA, DNA Bracelet, Tree of Traits, DNA Extraction, and Size of Things. In order to educate people about synthetic biology, we must first be sure that they understand basic biology concepts. This is why we chose these specific activities. Through these we are able to further develop basic knowledge of biology so that in the future we can accurately educate people about synthetic biology, specifically.

### **Twizzler DNA-**

This activity was adjusted to accommodate large crowds with children of all ages. Base pair matching was explained through directions on the wall with a display of what the finished product should have looked like. Each nucleotide base corresponded to a different colored marshmallow. The original protocol was designed to teach about base pairs and make the pairs on toothpicks before adding the twizzlers for the backbones. The idea of base pairing was not understood by many that did this activity, as was evident when the marshmallows were randomly placed on toothpicks. The idea of twisting DNA into a double helix was understood by most. While the concept of base pairing was mostly lost on this audience in the absence of direct explanations from a facilitator, the activity was successful in helping participants understand the general helical, ladder-like structure of DNA. The station got crowded very easily because it took some time to complete and younger children did not understand the activity without a parent to assist them.

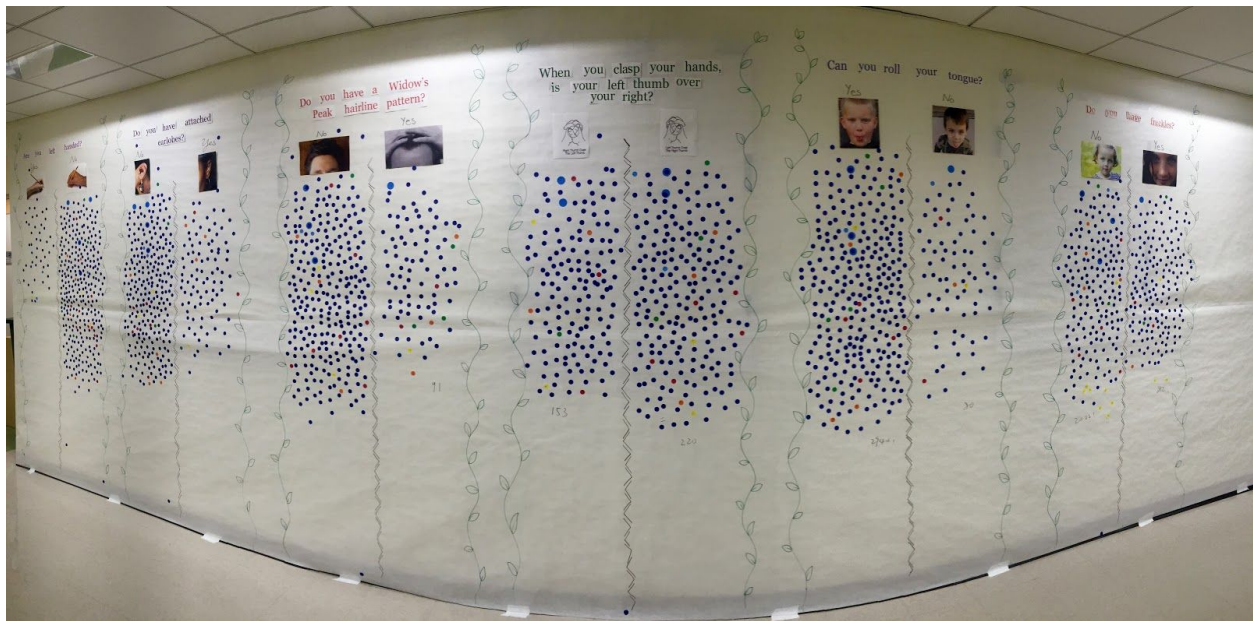
### **DNA Bracelet-**

This activity was completed according to the protocol in the manual “Synthetic Biology Teacher Curriculum.” The traits that were used for the bracelets matched those used in the Tree of Traits (attached earlobes, widow’s peak, handedness, tongue rolling, which thumb is on top when hands are interlocked, and freckles). This activity worked

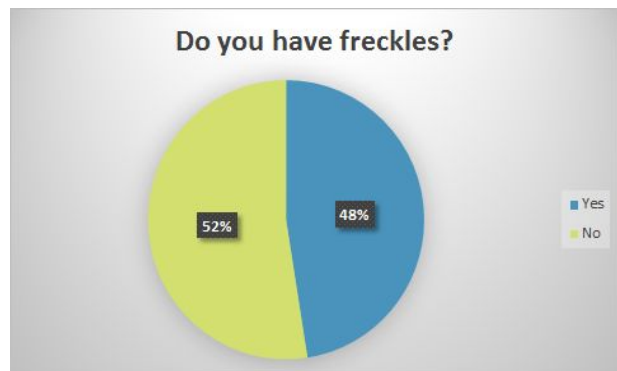
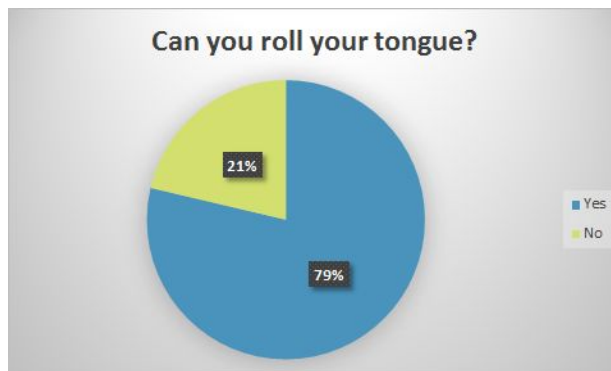
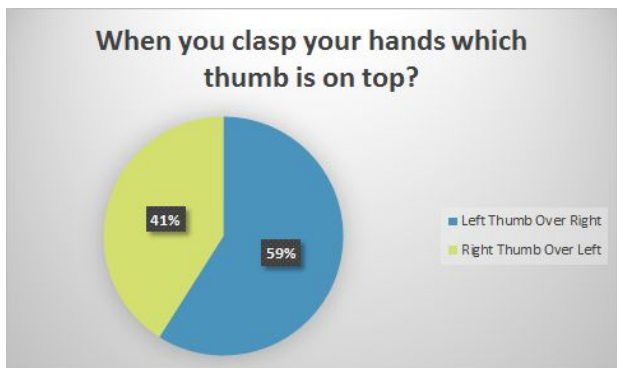
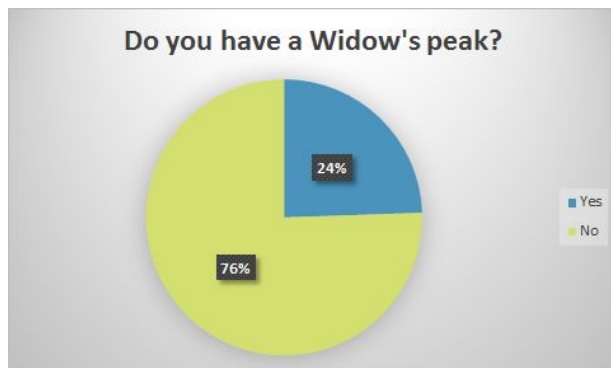
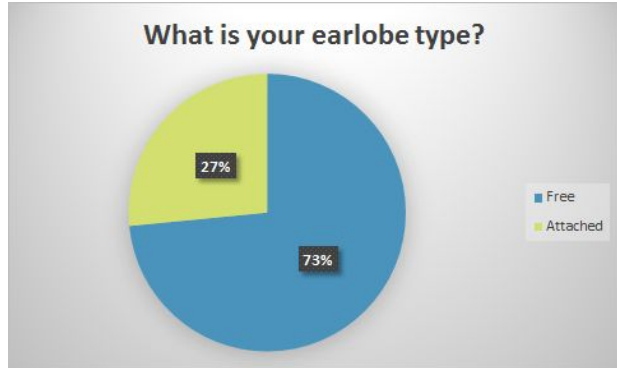
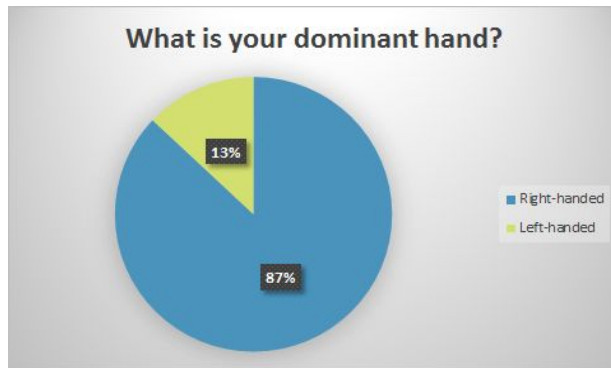
well with the amount of people that we had and the age range. Many children were able to recognize that their bracelets were different because they looked different. Some older children were able to recognize that their bracelets were similar to people they were related to because of traits being passed down from their parents to them.

### Tree of Traits-

For this activity, we covered a hallway wall with white paper and made columns with either/or questions that correspond to the DNA bracelet activity. Participants could put stickers in the column for the response to the question that matched the genetic traits that they had (see image below).



This was a very popular activity, as all ages could participate. The parents or guardians of the younger children could explain what the questions meant and informed the child which traits they had so that the child could put the sticker in the correct column. We ran into problems with people not being sure if they had attached or free earlobes, some even running to the bathroom to check in the mirror. For the most part, the group members could tell each other if they had free or attached, but even then they were not entirely sure if they were correct. Two other questions that had similar confusion were with the Widow's peak and if the participant had freckles. Because this activity relied on self-reporting data, the confusion of which column to put the sticker in may be reflected in further examination of the data. The responses from the questions asked are shown below.



In the data above, all of the dominant traits in the charts are shown in blue and the recessive traits are shown in green, with the exception of freckles, because the dominance is still not known. The prevalence of many of the traits was what we expected them to be based on data we found of the world's population. We would have expected that the data would reflect the dominant traits showing up more than the recessive, but we found this to not be true, specifically for the Widow's peak.

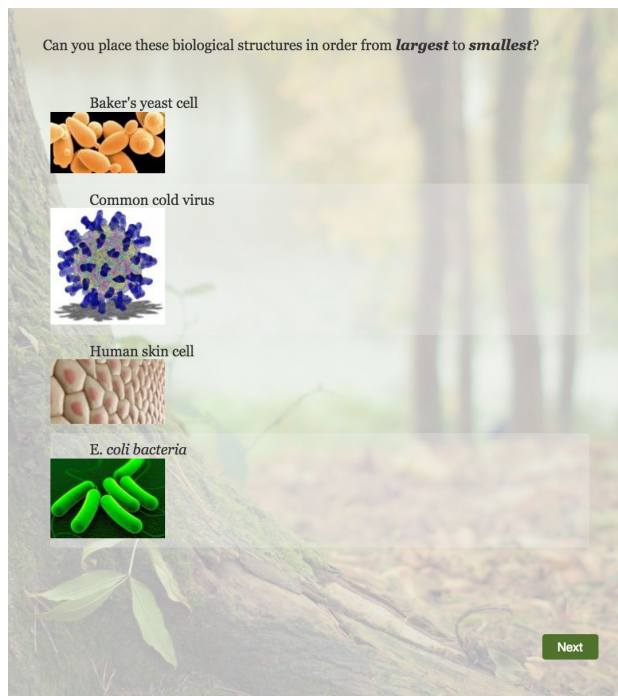
### **DNA Extraction-**

This activity had to be adjusted in order to accommodate for the large crowd of people at the TouchTomorrow event. The original protocol was designed on a

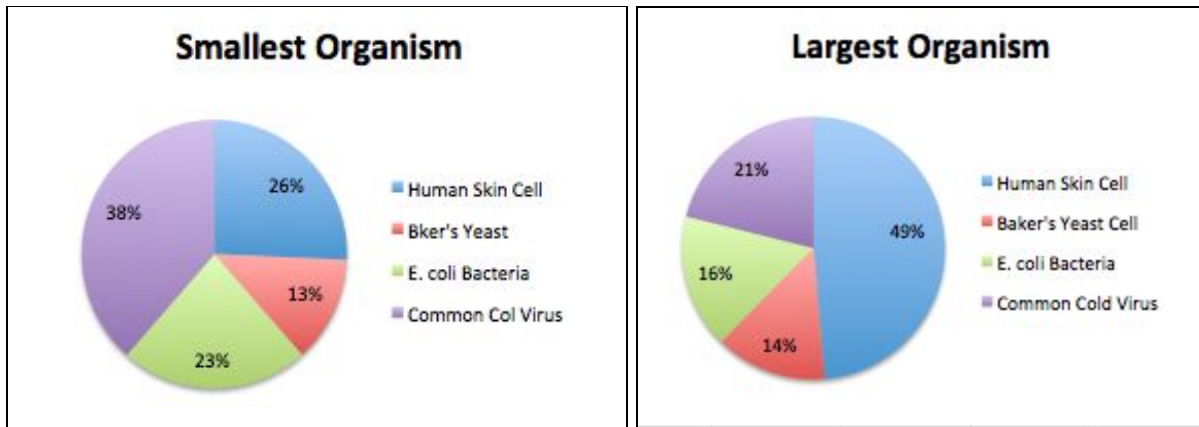
per-student basis in a classroom setting. We modified the extraction liquid protocol to make 8 times the original amount and made 3 Liters using the new recipe. The original procedure called for 1 tsp salt, 2 tsp soap, and 1/2 cup of water; this was modified to 946.4 mL water, 40g salt, and 80mL soap. Additionally, the original materials suggested using 1/4 banana per student; we modified this so that each participant received one strawberry. We found bananas had a low yield of DNA, so we ran some test trials with other fruits such as: apples, kiwis, grapes, strawberries, and blueberries. We found we were able to extract the most DNA from strawberries and blueberries, and ultimately chose strawberries for their relatively low cost, high DNA yield, and because they are individual pieces that do not need to be cut up further. To accommodate the approximately 400 participants for this activity, we purchased 20 lbs of strawberries, and the other supplies (cups, stirrers) in bulk.

## Size of Things

This activity was modified from a classroom setting of paper quiz with an associated online portion to strictly an online quiz. The quiz was presented on iPads and was designed using the survey platform Qualtrics, though other open-source survey tools like Survey Monkey and Google Forms would also be suitable. The list of questions as presented to the participants, along with the results, are shown below. Related facts followed each of the questions.







Almost! The correct order from largest to smallest is a human skin cell, Baker's yeast, *E. coli* bacteria, and then a common cold virus.

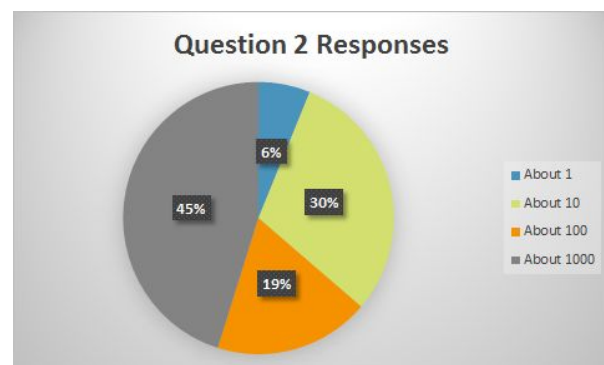
Fun Fact: almost 80 viruses could fit on one skin cell! Better wash your hands :)

What is the smallest number of human skin cells that can be seen with the naked eye?

- About 1
- About 10
- About 100
- About 1000



Next



Nice try! The smallest number of human skin cells that can be seen with the naked eye is about 10.

Did you know that humans have around 1.6 trillion skin cells on their bodies and also shed close to 40,000 of those cells every hour. Gross!!

If you stretched out all of the DNA in one of your cells, do you think it would be taller or shorter than you?

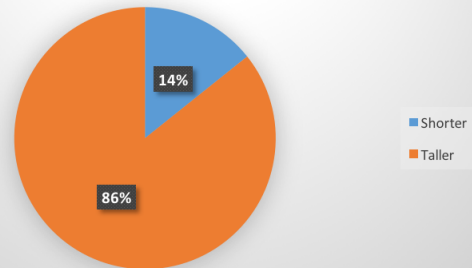
Taller

Shorter



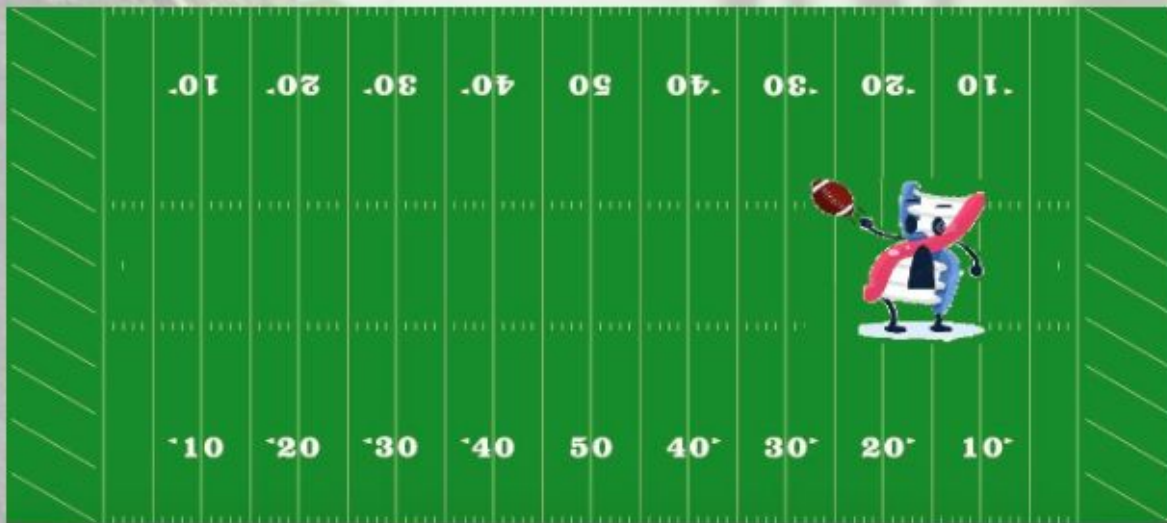
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Question 3 Responses



Actually, the total height of the DNA in a single cell stretched out would actually be about 10 feet! So unless you're a giant it is taller than you.

That means it would only take about 30 cells worth of DNA to score a touchdown from from one end zone to the other!!



The pineal gland is the smallest organ in the human body, about the size of a grain of rice (5-8 mm).

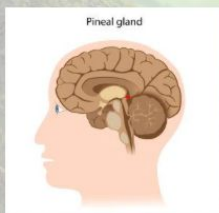
How many cells do you think make up this organ?

About 20 cells

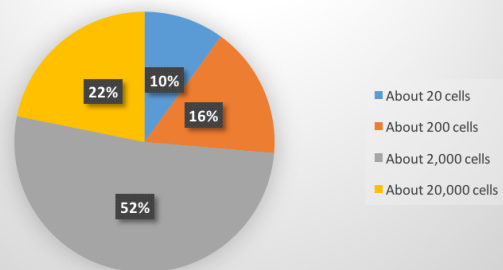
About 200 cells

About 2,000 cells

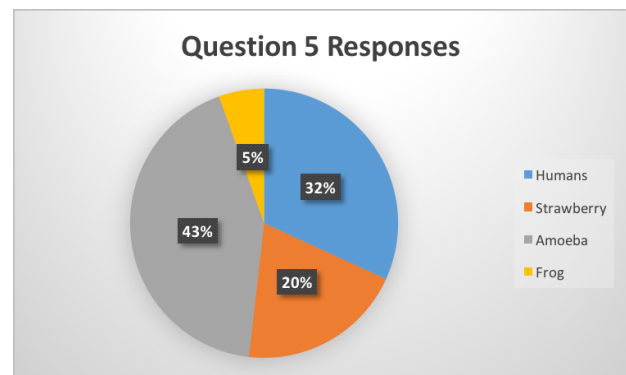
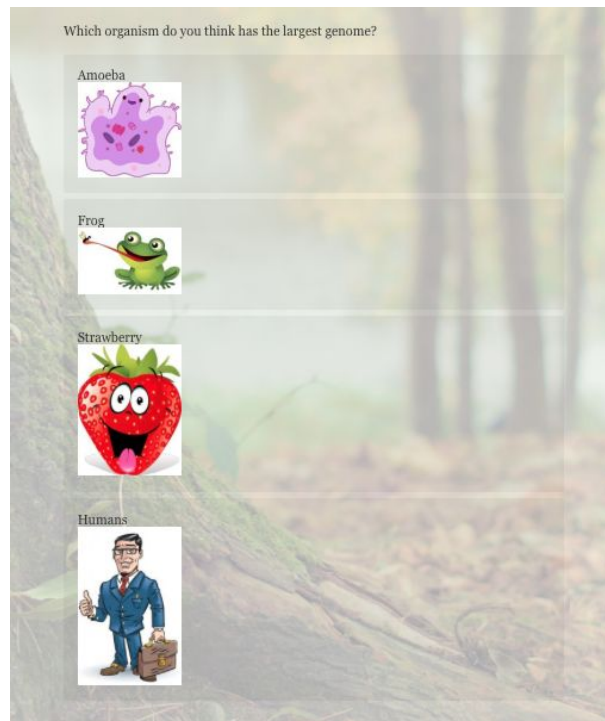
About 20,000 cells



#### Question 4 Responses



Surprisingly, even though it is the size of a grain of salt there are about 2,000 cells that make up the pineal gland.

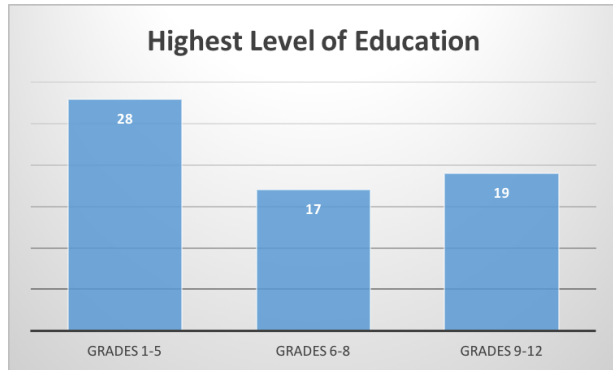
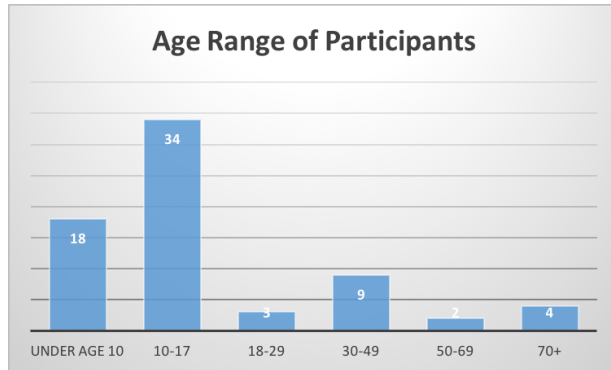


The amoeba, actually, has the largest genome of any organism. Having more than 10 times the genetic material as the next closest.

Humans, despite being the most advanced organism, actually has the the smallest genome out of the organisms from the previous questions. Weird!

After the quiz was over, the participants could opt to take a quick demographic survey asking what age range they fall into and the highest level of education they had received at that point. Of the 98 participants that made it to that point, 71 agreed to participate in the two demographic questions.





We originally thought that children under the age of 18 would have more knowledge of biological concepts than people over the age of 18. This is because biology is taught in all grade levels today, however 10 years ago this subject was not taught in depth. Overall, we found that age did not have a significant impact on the amount that a person knows about biological concepts. There was no correlation between age and the amount of questions that were answered correctly.

## Women in Science

The Women in Science day camp was held at WPI that our iGEM team volunteered to help run. This camp was aimed for girls ages 8 to 13 to introduce them to the field of biology and get them interested in STEM. We had the girls do the strawberry and blueberry DNA extraction, run rainbow gels, and take the Size of Things Quiz. For this camp, we adapted the activities from the “Synthetic Biology Teacher Curriculum” and the TouchTomorrow event held earlier in the year but changed some of the specifics.

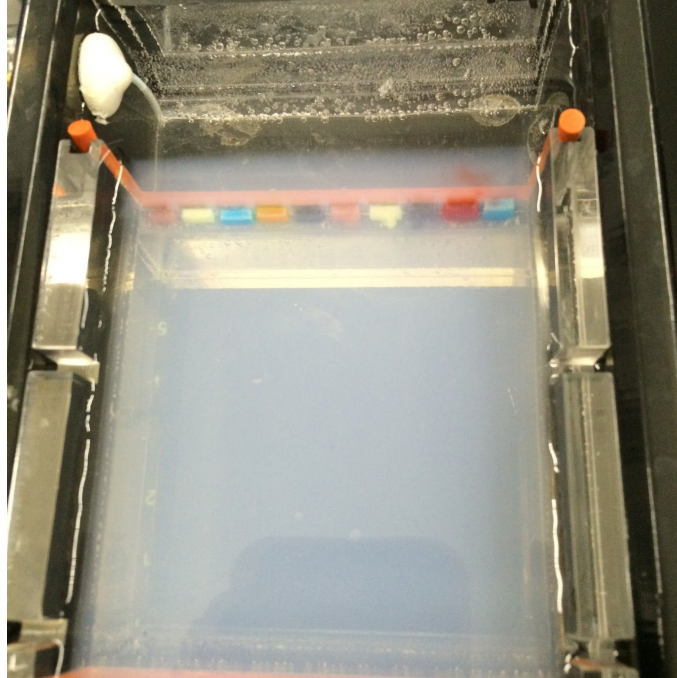
### **Strawberry DNA Extraction**

For this activity, we modified it to provide more quantitative data for the girls to analyze. The girls were split into two groups, one that extracted DNA from blueberries and one from strawberries. They were asked to weigh out 20g of their assigned fruit with a 0.5g range of error and place the fruit in a Ziploc bag. After pipetting 10mL of the DNA extraction liquid into the bag, they mashed the fruit up and filtered out the pulp using a paper towel to collect only the liquid in a cup. They added 20mL of cold isopropyl alcohol to the cup to extract the DNA. After stirring, they carefully filtered out the DNA from the mixture into a test tube using a new paper towel. They learned how to tare the balance using an empty test tube, then recorded the weight of their own fruit’s DNA. By the end of the camp, we had collected data from all of the girls to compare which fruit yielded the most DNA using the same amounts of starting materials.

### **Rainbow Gels**

For this activity, we prepared tubes of color and gels in advance. The tubes of color were comprised of 50 ul water, 50 ul glycerol, and a pinch of kool-aid powder. The gels were made of 0.6g agarose and 60 ul of slightly salted water. The boxes were also filled with slightly salted water for the gel to run through.

The girls were able to mix together different colors into tubes. They then put 15 ul of their color into the gel wells. The power supply was turned up to 180 volts and let them run for about 15 minutes. After the gels ran about half way, we were able to take them out and the girls were able to cut their lanes away from their partners. This allowed the girls to take home their colored gels in plastic bags.



### **Size of Things Quiz**

For this activity, we used the same quiz that we designed for the TouchTomorrow event (see above). We took away the demographics questions for the quiz we gave to the girls because through the camp we knew their age group.

We found that the data from the quiz given during the TouchTomorrow event was very similar to the data from the quiz given during the Women in Science camp. Most girls were able to identify that DNA is taller a human when stretched out, while most were unable to identify that amoebas have the largest genome. This data further disproves our theory that children under the age of 18 would have more knowledge of biology concepts than adults. We can conclude there is no correlation between age and the amount of known about biological concepts.